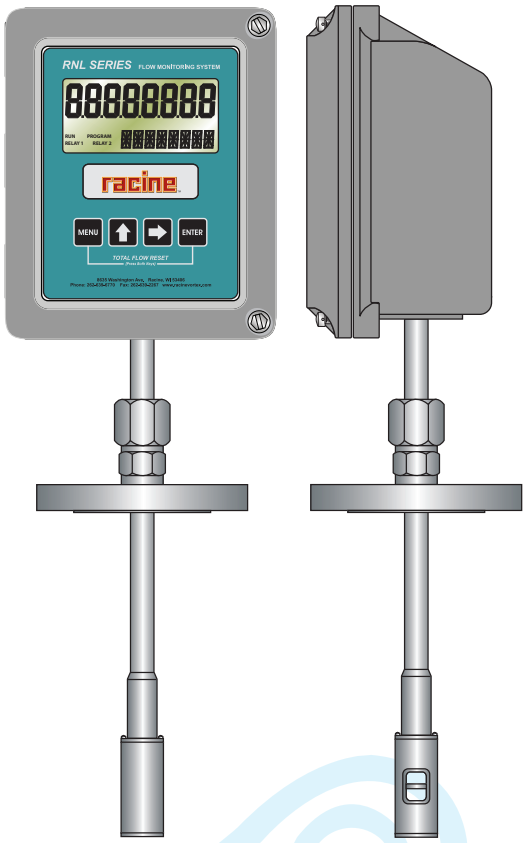
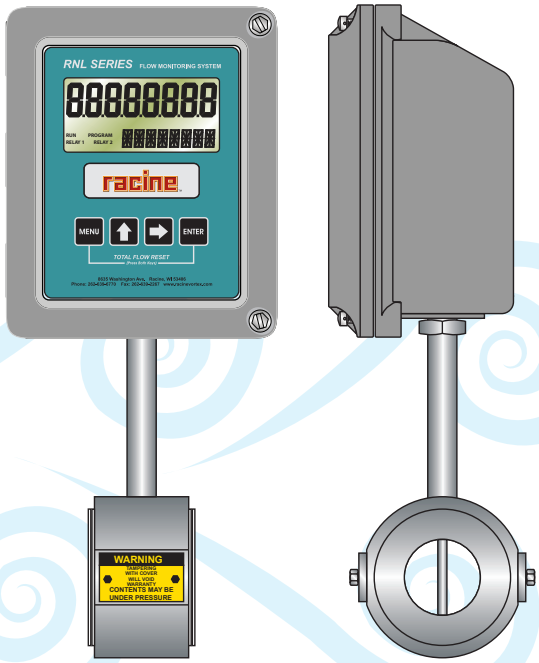
racine™ Operator's Manual

RNL Insertion Style Flow Meter
RWL Wafer Style Flow Meter





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INTRODUCTION

The RxL series flow meters are designed to provide accurate and repeatable liquid flow measurement in designated engineering units. The flow meters employ a patented ultrasonic technique to measure a form of turbulence created in the flow stream. This turbulence, know as Von Karman Vortex Street, is related to the volumetric flow through the pipe.

The flow meters primary output is a 4-20 milliampere (mA) current source whose current output is proportional to the flow. The secondary output is a pulse train whose frequency is directly proportional to the flow.

Each RxL series flow meter is calibrated against flow standards traceable to NIST (National Institute of Standards and Technology).

The RWL series flow meters are for pipe inside diameters of 1, 1½, 2 and 3 inches.

The RNL Flow meter is an insertion style retractable flow meter that is installed through a 2” full port isolation valve, which permits the unit to be retracted or inserted manually without shutting down the system.

These flow meters are calibrated in actual volumetric flow rates, such as gallons per minute (GPM).

INSTALLATION

Mechanical Installation

The flow meter has been shipped completely assembled, tested and ready to install and operate in its permanent location. ***See Figures 2 and 3*** for the applicable outline dimensions for the flow meter.

Installation Location

The RxL series flow meters use a combination of ultrasonic and vortex shedding technologies to measure volumetric flow. An ultrasonic noise can interfere with this technique, therefore high intensity ultrasonic noise sources should not be located upstream or downstream from the sensor. Common ultrasonic noise sources include the following:

1. Slightly open valves operating with large pressure drops.
2. Small pipe leaks in high pressure systems.
3. Venturis operating at near-sonic flow rates.
4. Sonic nozzles.

If these ultrasonic noise sources cannot be eliminated, the meter should be mounted with at least one elbow between the flow meter and the noise source.

The sensor should be installed with at least 20 pipe diameters of straight pipe upstream and 10 pipe diameters downstream. This condition provides a fully developed, symmetrical flow profile that is necessary to obtain accurate and repeatable results. Shorter upstream/downstream piping may be used, although a shift in calibration may occur. If severe turbulence or distorted flow profiles are present, flow straighteners should be used.

Consult Racine Federated for shorter upstream/downstream configurations. ***See Appendix*** for additional installation information.

When installing the flow meter in a newly constructed process line, a strainer should be installed upstream of the meter to prevent foreign material from damaging the strut or obstructing the flow. Excessive damage to the strut could affect the accuracy of the meter.

In order to prevent cavitation, it is important that the required back pressure be maintained. The minimum required back pressure varies with temperature. See the back pressure calculations in ***Figure 1***. The sensor should be installed using the minimum piping requirements indicated in ***Table 2***.

TABLE 1 - SPECIFICATIONS	
MEASURED	Liquid in pipe from ½" (13 mm) diameter
FLOW RATE MEASURED	For RNL Series 2 to 16 FPS (0.61 to 4.9 MPS) For RWL Series 2 to 20 FPS (0.61 to 6.1 MPS) see applicable FLOW RANGE charts
PROCESS TEMPERATURE	For RNL Series Maximum 250 °F (121 °C) For RWL Series -20 °F to 300 °F (-29 °C to 148 °C)
AMBIENT TEMPERATURE LIMITS	For RNL Series -20 °F to 110 °F (-29 °C to 43 °C) For RWL Series -20 °F to 150 °F (-29 °C to 66 °C)
PROCESS PRESSURE	For RNL Series Up to 250 PSIG (17 BARg) For RWL Series Maximum @ 100 °F: 300 PSIG (20 BARg) Maximum @ 300 °F: 200 PSIG (14 BARg)
MINIMUM BACK PRESSURE	***See Figure A*** - BACK PRESSURE CALCULATIONS
MAXIMUM VISCOSITY	10 centistokes
ACCURACY	For RNL Series ±2.0% of reading For RWL Series ±1.0% of reading
REPEATABILITY	±0.5% of reading
RESPONSE TIME	1 second
INPUT POWER	4-20 mA Loop Powered +10 to +30 VDC , 25 mA max
DISPLAY	8 digit, .75" high numeric display 8 character, .38" high alphanumeric
ANALOG OUTPUT	4-20 mA Current loop Resolution 1:4000 Transient Overvoltage**:** Category 3, in accordance with IEC 664
PULSE OUTPUT	Outputs one pulse for each increment of the least significant digit of totalizer Pulse Type: Opto-Isolated open collector transistor Max. Voltage: 30 VDC Pulse Width ON State: 20 ms / Max pulse rate 25 Hz Current (ON State): 0.9 V drop @ 5.0 mA or 0.7 V drop @ 0.1 mA
CONSTRUCTION	For RNL Series NEMA 4 rated electronics housing Stainless steel w/PPS transducer assembly **Standard:** 2" ANSI 150 lb flange **Optional:** 300 lb flange or ¾ NPT x 2 NPT Bushings For RWL Series NEMA 4 rated electronics housing Flange Compatibility ANSI 150, 300, 600 lb flanges DN 25 - 40 - 50, 80 flanges
ENVIRONMENTAL	Operating Temperature: -22 °F (-30 °C) to 158 °F (70 °C) Humidity: 0-90% Non-condensing

TABLE 2 - FLOW RANGES				
NOMINAL SIZE INCH (mm)	**GALLONS PER MINUTE (GPM)**		**LITERS PER MINUTE (LPM)**	
	Minimum Flow	**Maximum Flow**	**Minimum Flow**	**Maximum Flow**
RNL Series				
4.0 (100)	79	635	300	2,403
6.0 (152)	180	1441	682	5,454
8.0 (203)	312	2,495	1,181	9,444
10.0 (254)	492	3,933	1,861	14,886
12.0 (305)	698	5,582	2,641	21,130
14.0 (356)	843	6,746	3,192	25,537
16.0 (406)	1,102	8,813	4,170	33,360
18.0 (457)	1,394	11,155	5,278	42,226
20.0 (508)	1,733	13,864	6,560	52,481
RWL Series				
1.0 (25)	3.7	38	14	142
1.5 (40)	9.3	93	35	350
2.0 (50)	15	150	57	568
3.0 (80)	37	370	140	1,402
BASED ON WATER AT 1 CENTISTOKE AT 73 °F, SCHEDULE 40 PIPE 1 TO 20 FPS (0.3 TO 6 MPS) FOR REFERENCE ONLY, CONSULT RACINE FEDERATED SIZING PROGRAM FOR TEMPERATURE AND PRESSURE CONDITIONS OTHER THAN THOSE LISTED HERE				

BACK PRESSURE CALCULATIONS

At high flow rates, cavitation may occur, causing a flow meter to be inaccurate. Cavitation can be prevented by increasing the back pressure. The following equation determines the minimum back pressure required to prevent cavitation:

$$P_1 = P_{VP} + 0.03\ V^2$$

where: P_1 = line pressure at the meter PSIA
P_{VP} = vapor pressure of the liquid PSIA
V = line velocity FPS

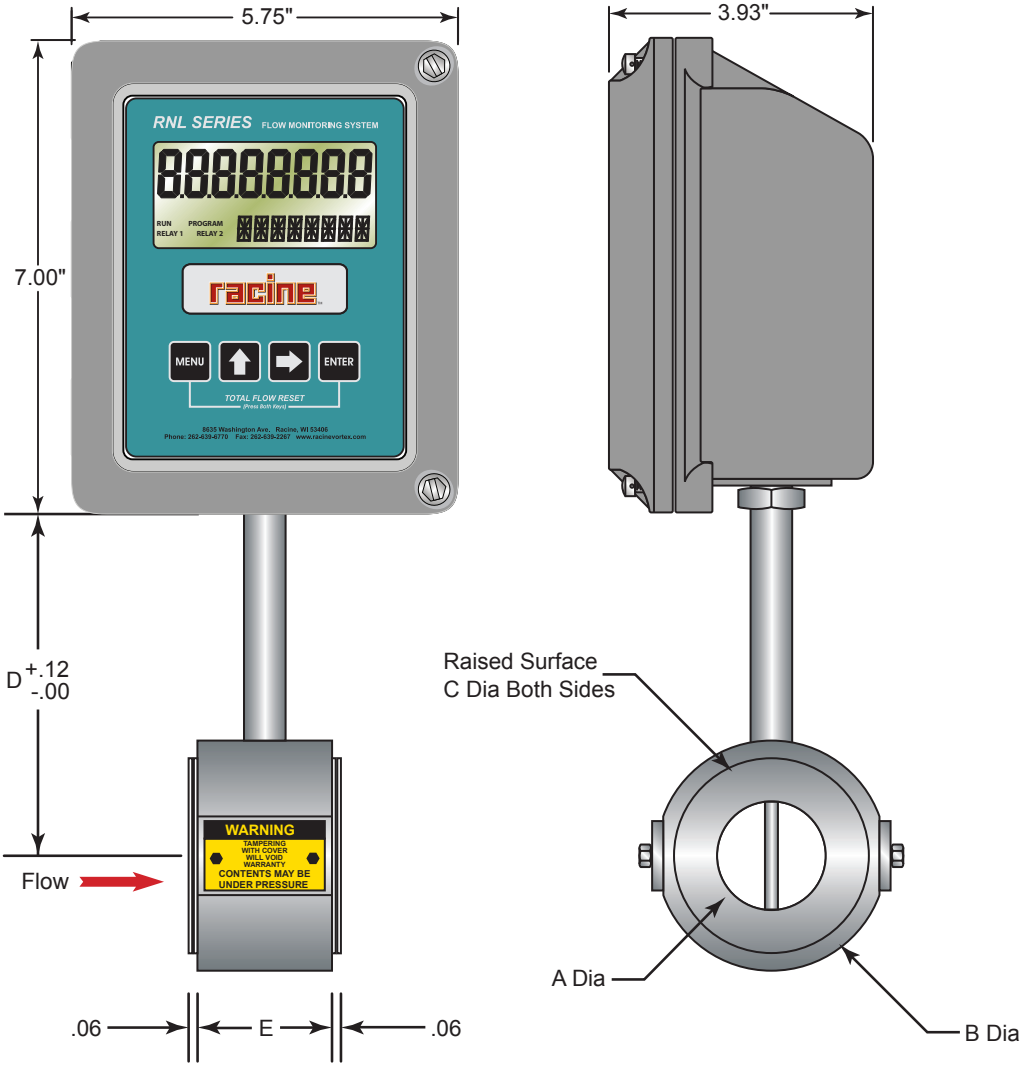
EXAMPLE: In water at 65 °F flowing with a speed of 25 fps, the vapor pressure is 0.3 PSIA.

$P1 = 0.3 + 0.03\ (25)^2 = 19.05$ PSIA If atmospheric pressure is 14.69 PSIA,:

Then P1 = 19.05 PSIA - 14.69 PSIA = 4.36 PSIG

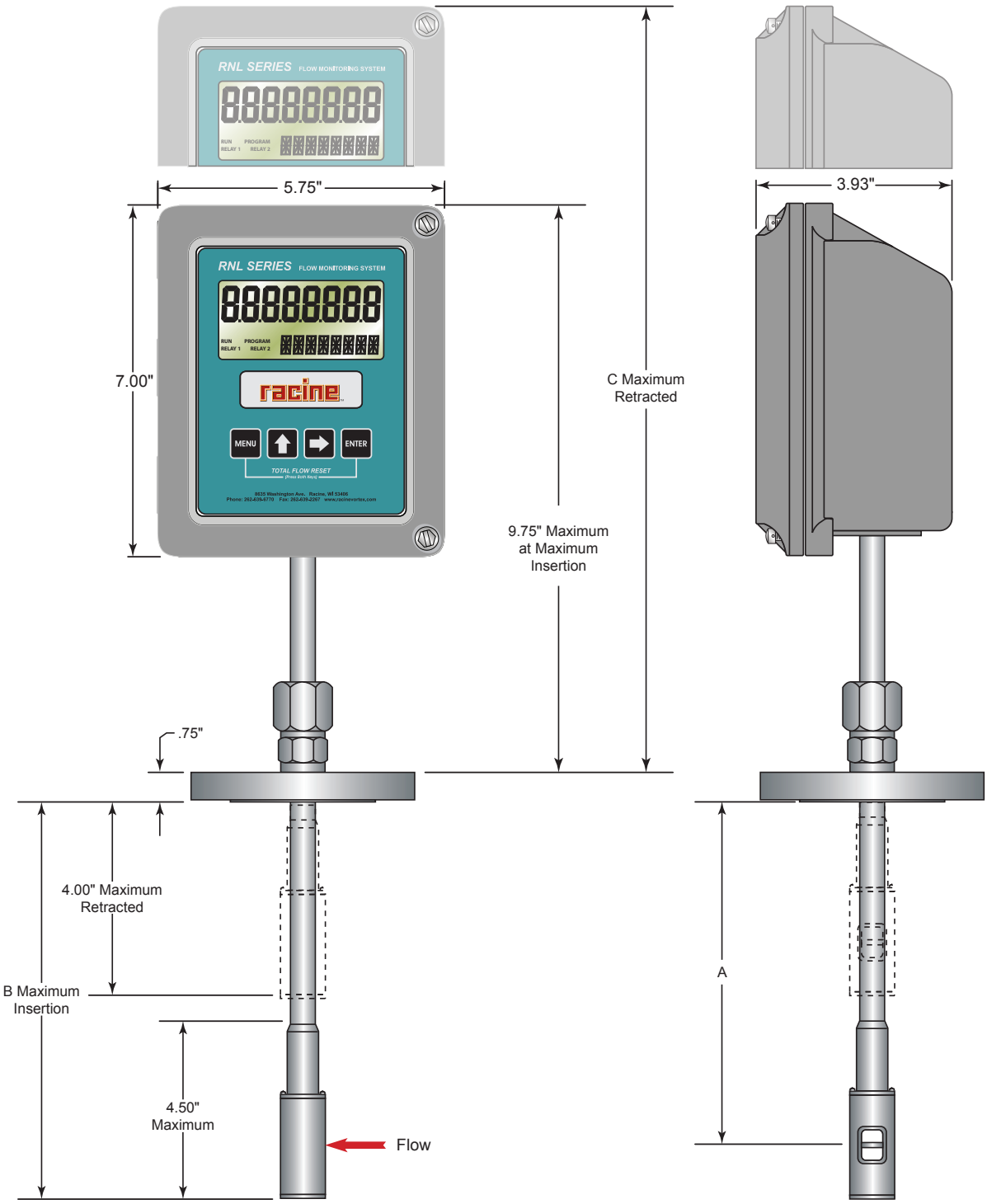
Maintaining a back pressure of 5 PSIG or greater will prevent cavitation.

FIGURE 1 - BACK PRESSURE CALCULATIONS



MODEL	NOMINAL SIZE	A	B	C	D	E
RWL10	1.00 (25)	0.88 (22)	2.62 (67)	2.62 (67)	7.34 (186)	2.12 (54)
RWL15	1.50 (38)	1.38 (35)	3.37 (86)	3.37 (86)	7.71 (196)	
RWL20	2.00 (51)	1.75 (45)	4.00 (102)	4.00 (102)	8.03 (204)	
RWL30	3.00 (76)	2.75 (70)	5.00 (127)	5.00 (127)	8.53(217)	2.38 (61)
All dimensions are in inches (mm)						

FIGURE 2 - OUTLINE DIMENSIONS FOR RWL SERIES FLOW METERS



A	B	C
12.00 (305)	13.125 (333)	18.83 (478)
24.00 (610)	25.125 (638)	30.83 (783)
36.00 (914)	37.125 (943)	42.83 (1088)
All dimensions are in inches (mm)		

FIGURE 3 - OUTLINE DIMENSIONS FOR RNL SERIES FLOW METERS

FLOW METER INSTALLATION

RWL Series Flow meters

The RWL Series Flow meters are designed to mount between two ANSI flanges using the appropriate bolts. The flow meter should be mounted so its inside diameter is centered inside the pipe (***See Figure 4***). The labeling of the flow direction on the flow meter should be aligned with the flow in the pipe

Note: *Gaskets (not provided) are necessary between the ANSI flanges. Insure that these gaskets are properly installed and do not protrude into the flow stream.*

CAUTION: Avoid bending the vortex strut or damaging the transducers during installation. Do not remove cover plates while unit is operating

Note: *See Appendix A for additional installation information.*

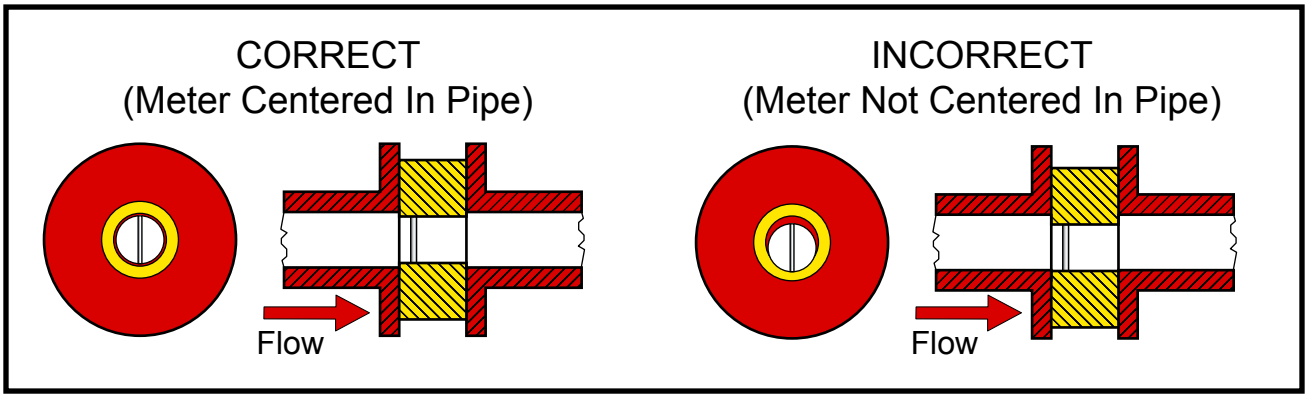


FIGURE 4 - INTERNAL ALIGNMENT OF RWL SERIES FLOW METERS

RNL Series Flow metes

The RNL Series flow meters are designed to mount on a standard ANSI 150 lb., 2” pipe flange. It is recommended that the customer conduct a flow profile survey and place the probe at the optimum point. The labeling of the flow direction on the sensor should be aligned with the flow in the pipe. Maximum insertion depth is a product of pipe size and fluid velocity, ***see Appendix Table 6*** for Insertion Depth Chart.

CAUTION: Avoid bending the vortex strut or damaging the transducers during installation. The torque value for the Conax fitting is 90-100 ft. lbs.

Note: *See Appendix A for further information on installation.*

TABLE 3 - MINIMUM PIPING REQUIREMENTS	
Upstream Obstruction	**Minimum Required Straight-run Pipe Diameters Upstream from Meter**
90° Elbow	10
Two 90° Elbows, Same Plane	15
Two 90° Elbows, Different Planes	20
Flow Straightener (recommended when ever an axial swirl exists in the flow stream)	10
Fully Open Shut-off Valve	5
Downstream Obstruction	**Minimum Required Straight-run Pipe Diameters Downstream from Meter**
Control Valve	5

Electrical Installation

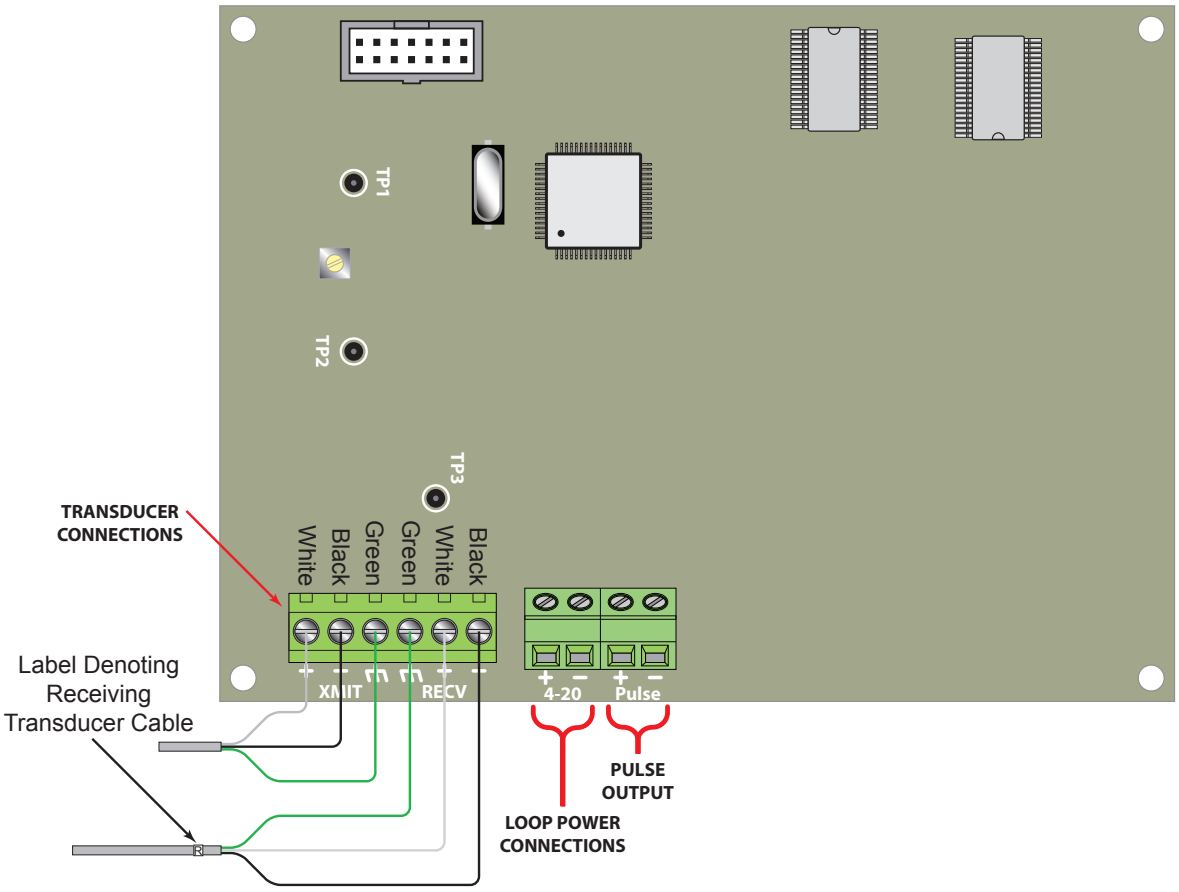


FIGURE 5 - FLOW METER TERMINAL FUNCTIONS

RWL and RNL Series Flow Meters

Electrical connections for the flow meter are made using screw-type terminals located inside the electronics enclosure. To expose these terminals, open the cover. The functions of these terminals are illustrated in ***Figure 5***.

Flow Meter Wiring

A two conductor cable of 16 to 24 AWG solid or stranded wire is required to make connections to the flow meter. It is recommended that a shielded interconnecting cable be used. The maximum cable length for the power depends on the supply voltage lines required to drive the flow meter and the current meter being used to monitor the current output of the flow meter. The maximum length of the cable is determined by using ***Figure 6*** to calculate the maximum load (resistance in Ohms) that can be driven using the known power supply voltage. In determining this value the voltage drop across the meter being used to monitor the current output of the flow meter must be considered. After this value has been found, ***Table 4*** can be used to calculate the resistance in the cable being used and adjust the input voltage as required.

TABLE 4 - LINE RESISTANCE FOR CURRENT LINES		
Ohms/Ft Related to Wire Size (AWG)		
16 AWG	=	0.00420 Ohm/Ft
18 AWG	=	0.00651 Ohm/Ft
20 AWG	=	0.01035 Ohm/Ft
22 AWG	=	0.01310 Ohm/Ft
24 AWG	=	0.02620 Ohm/Ft

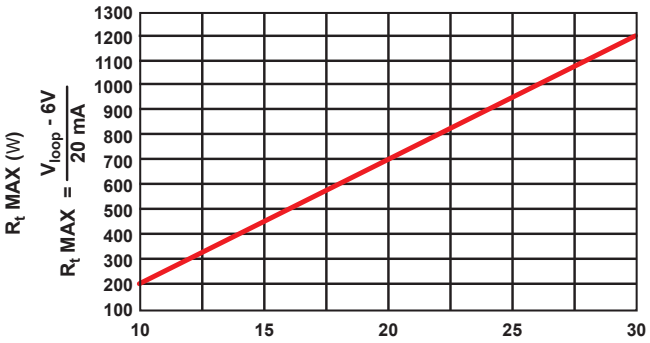


FIGURE 6 - LOAD RESISTANCE VS. SUPPLY VOLTAGE

Pulse Output

The pulse output is a secondary output and is not intended for long transmission. The load on the line must be 50 KΩ minimum and 1,000 picofarads (pf) maximum.

The maximum length of shielded cable that can be attached to this output is 100 feet.

Cable Installation

To install the cable in the flow meter, route the cable through the cable gland located on the electronics enclosure.

The wiring of the other end of the cable will vary depending on the specific installation requirements. ***Figures 7,8, and 9*** show the wiring diagram for variations of flow meter installation.

The flow meter's 4 position terminal strip provides all the connections needed to operate the flow meter.

+ 4-20 mA Terminals

The + 4-20 mA terminals are used for the flow meter's power supply. This power supply should be 10 to 30 VDC and be capable of supplying 25 mA to the flow meter. Because this meter has a built-in display no additional wiring is necessary for basic operation (***See Figure 7***).

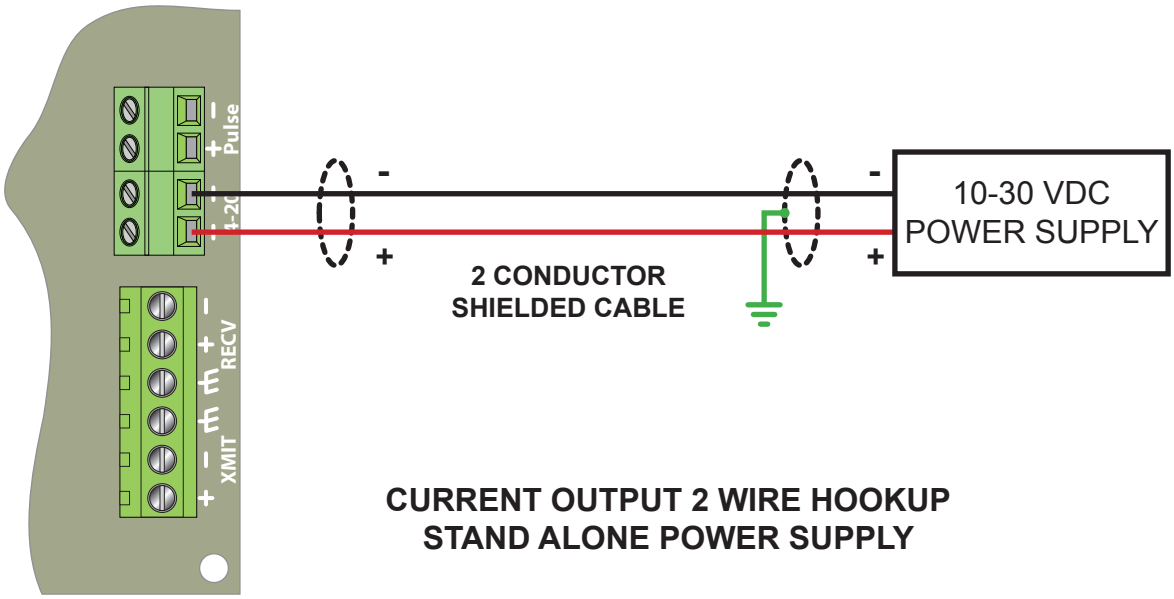


FIGURE 7 - EXAMPLES OF RNL AND RWL FLOW METER HOOKUPS
LOOP POWER, BASIC CONFIGURATION

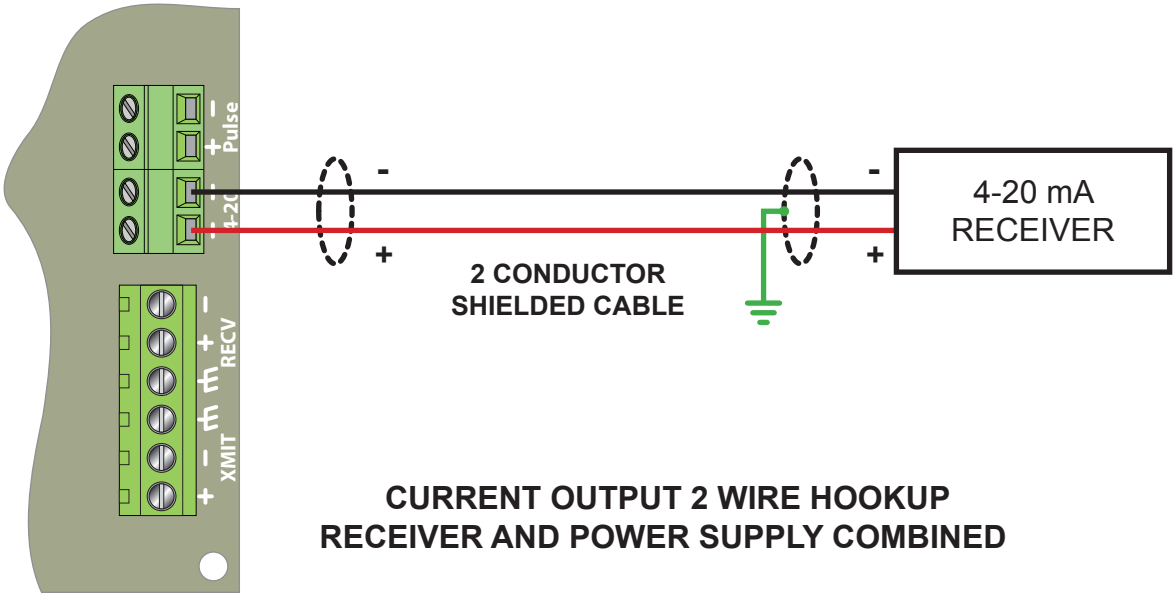


FIGURE 8 - EXAMPLES OF RNL AND RWL FLOW METER HOOKUP
LOOP POWER, RECEIVER COMBINED WITH POWER SUPPLY

If the current loop is used to transmit data the receiving device may also be the current source for the instrument (***See Figure 8***).

Finally the device used to measure the current can be installed in series with the return line as illustrated in ***Figure 9***. This output is a standard 4 to 20 mA output, where 4 mA corresponds to no flow and 20 mA indicates 100% (full scale) flow.

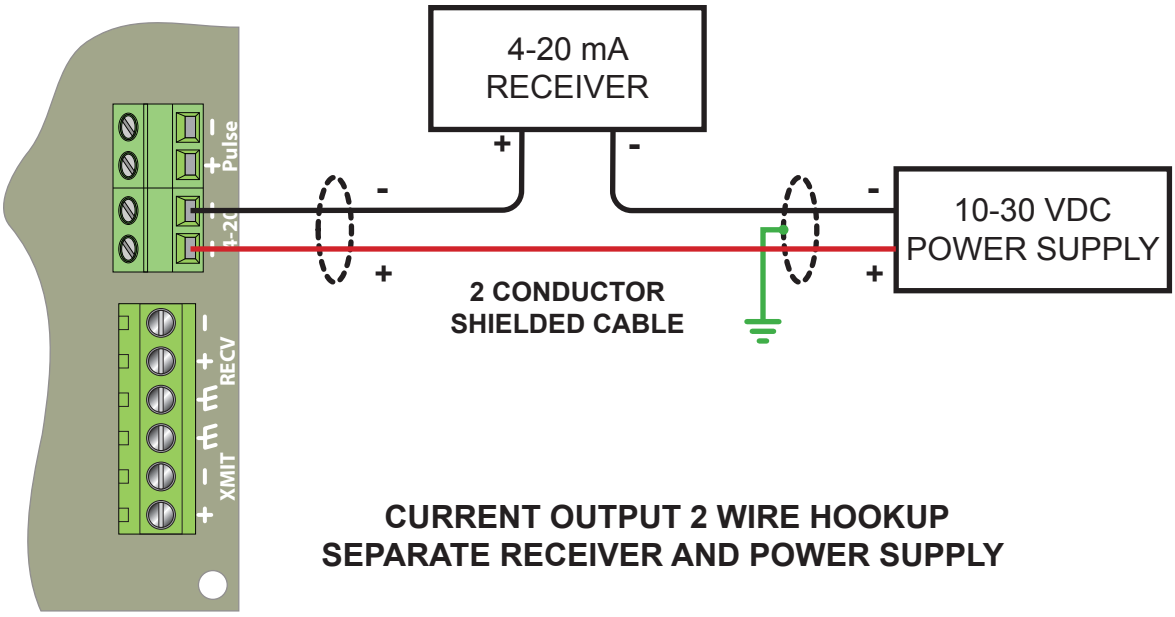


FIGURE 9 - EXAMPLE OF RNL OR RWL FLOW METER HOOKUP LOOP POWER, RECEIVER AND POWER SUPPLY SEPARATE.

If the pulse output function is to be used the receiving device must conform to the output parameters as described in the specifications section. Attach a cable as describe in to the Pulse output terminal and terminate the other end of the cable at the desired location.

OPERATING THE MONITOR

The monitor has two modes of operation, referred to as the **RUN** mode and the **PROGRAM** mode. Both the run mode and the program mode display screen enunciators confirming the state of the monitor. A quick glance at the lower left hand corner of the LCD screen will confirm operating status. Normal operation will be in the run mode. To access the programming mode, press the **MENU** key once. The programming indicator will appear signaling that the display is ready to accept programming inputs. After programming the display with the necessary information, a lock out feature can be turned on to prevent unauthorized access or changing the meter's setup parameters.

BASIC PROGRAMMING MODE

Keys:

MENU - Switches to PROGRAMMING mode.

Up Arrow (⬆) - Scrolls forward through the parameters choices and increments numeric variables.

Right Arrow (➡) - Scrolls backward through the parameters choices and moves the active digit to the right.

ENTER - Used to save programming information, advance to the next programming parameter, and in the reset process.

Modes:

RUN – Normal operating mode.

PROGRAM – Used to program variables into the display

Entering Programming Mode – Change to programming mode by pressing the **MENU** key once. The mode indicator will change from RUN to PROGRAM

Select The ID Unit– At the **ID UNIT** prompt press the **ENTER** key once. The current ID (inside diameter) unit will begin to flash. Using the arrow keys choose **INCH** for US measurements or **MM** for metric measurements. Press **ENTER** once to save the meters ID Unit choice and advance to the pipe ID selection.

Select The Pipe ID – At the **ID** prompt press the **ENTER** key once. The current meter ID (inside diameter) will begin to flash. Using the arrow keys enter the pipe inside diameter. Press **ENTER** once to save the pipe ID.

Note: Specification charts for common types of pipes can be found in the appendix of this manual.

Select The Display Function – The monitor can display **RATE** or **TOTAL** or alternate between **BOTH** rate and total. At the **DISPLAY** prompt press the **ENTER** key once. The monitor now shows the display mode currently in effect. If the current selection is correct, press the **ENTER** key to advance to the next parameter. To change to an alternate display mode, use the arrow keys to scroll to the desired display mode and press **ENTER** to save the choice.

A **TEST** function is also available in the Display Function sub-menu. With the test function selected the display acts like a frequency counter and displays the raw input frequency being supplied to the frequency input terminals. The second line of the test screen shows transducer signal strength.

Select The Rate Unit – The monitor can display rate in any of the following units

If the current selection is correct, press the **ENTER** key to advance to the next parameter. To change to an alternate rate unit, use the arrow keys to scroll to the desired display units and press **ENTER** to save the choice.

- *Velocity measurements not available as totalizer units.

****- *Mass units require entry of specific gravity.***

Velocity*	
Feet	VEL FEET
Meters	VEL MTRS
Volumetric	
Gallons	GALLONS
Liters	LITERS
Millions of Gallons	MGAL
Cubic Feet	CUBIC FT
Million Cubic Feet	M CU FT
Cubic Meters	CUBIC ME
Million Cubic Meters	MEGL TRS
Acre Feet	ACRE FT
Oil Barrels (42 GAL)	OIL BARR
Liquid Barrels (31.5 GAL)	LIQ BARR
Mass**	
Kilograms	KGS
Pounds	LBS

Select The Rate Interval – The monitor can display rate interval in any of the units listed at the right.

Interval	Displayed as
Seconds	SEC
Minutes	MIN
Hours	HOUR
Days	DAY

If the current selection is correct, press the **ENTER** key to advance to the next parameter. To change to rate interval, use the arrow keys to scroll to the desired interval and press **ENTER** to save the choice.

Select the Totalizer Units - The flow totalizer unit is used to set the flow totalizer exponent. This feature is useful for accommodating a very large accumulated flow. The exponent is a x10n multiplier, where "n" can be from **-1 (x0.1)** to **+6 (x1,000,000)**. **Table 5** should be referenced for valid entries and their influence on the display.

Table 5 - Exponent Multipliers

Exponent	Display Multiplier
E-1	x 0.1
E0	x 1 (no multiplier)
E1	x 10
E2	x 100
E3	x 1,000
E4	x 10,000
E5	x 100,000
E6	x 1,000,000

If the current selection is correct, press the **ENTER** key to advance to the next parameter. To change to rate interval, use the arrow keys to scroll to the desired interval and press **ENTER** to save the choice.

This completes the basic setup for the meter.

Additional Scaling Parameters

Specific Gravity (SP GRAV)- The specific gravity for the fluid being measured must be entered if mass readings are desired. The **SP GRAV** (specific gravity) prompt will only be displayed when one of the mass **Rate Units** is chosen.

Low Flow Cutoff (FL C OFF) - The low flow cutoff is entered as a percentage between maximum flow and minimum flow and influences how the flow meter will act at flows very near zero. Generally, an entry of 2% provides for a stable zero indication. When the flow rate drops below the entered percentage value, the meters's display will read zero.

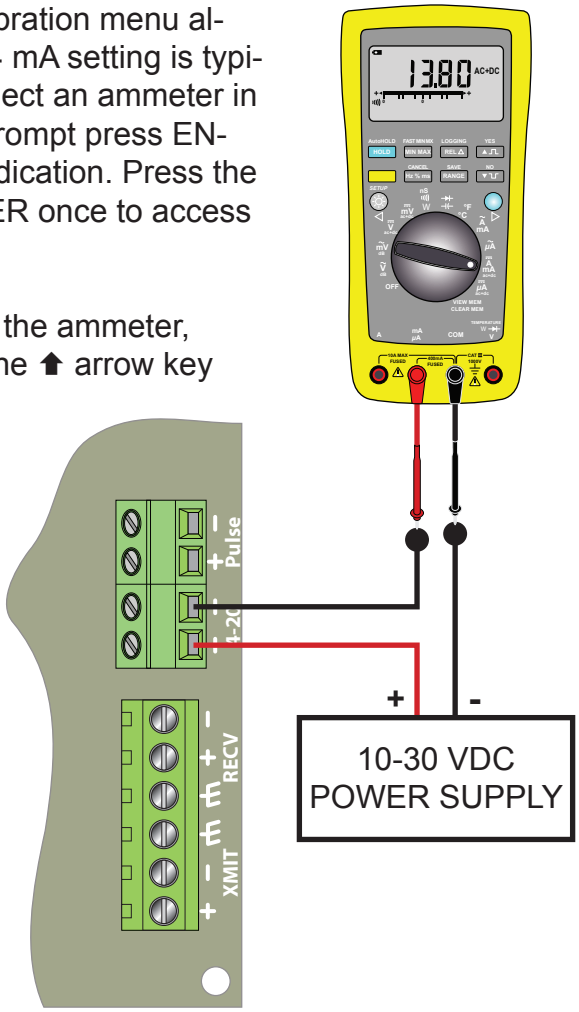
Damping (DAMPING) - The damping value is increased to increase stability of the flow rate readings. Damping values are decreased to allow the flow meter to react faster to changing flow rates.

Flow 4 mA Setting (FLOW 4MA) - If the 4-20 mA analog output is to be used the flow rate that corresponds to 4 mA must be set. If the current selection is correct, press the **ENTER** key once to advance to the next parameter. If adjustment is required, use the arrow keys to input the correct 4 mA setting. The ➡ arrow key moves the active digit one place to the right for each press of the key. The ⬆ arrow key increments the active digit one integer for each press of the key. When the correct 4 mA flow rate has been entered press ENTER once to store this value and move to the next parameter.

Flow 20 mA Setting (FLOW20MA) - If the 4-20 mA analog output is to be used the flow rate that corresponds to 20 mA must be set. If the current selection is correct, press the **ENTER** key once to advance to the next parameter. If adjustment is required, use the arrow keys to input the correct

20 mA setting. The ➡ arrow key moves the active digit one place to the right for each press of the key. The ⬆ arrow key increments the active digit one integer for each press of the key. When the correct 20 mA flow rate has been entered press ENTER once to store this value and move to the next parameter.

4-20 mA Calibration (4-20CAL?) - The 4-20 mA calibration menu allows the fine adjustment of the 4-20 mA output. The 4 mA setting is typically between 35 and 50. To set the 4 mA value, connect an ammeter in series with the loop power supply. At the 4-20CAL? prompt press ENTER once. The display will now show a steady NO indication. Press the ⬆ arrow key to change to a YES display. Press ENTER once to access the 4 mA fine adjustment.



4 mA Adjustment (4MA OUT) - While monitoring the ammeter, adjust the 4 mA value to obtain a 4 mA reading. The ⬆ arrow key increments the value and the ➡ arrow key decrements the value. When a steady 4 mA reading is obtained on the ammeter press the Enter key to lock in this value and move to the 20 mA adjustment.

20 mA Adjustment (20MA OUT) - The 20 mA adjustment is preformed using the same procedure as the 4 mA adjustment.

While monitoring the ammeter, adjust the 20 mA value to obtain a 20 mA reading. The ⬆ arrow key increments the value and the ➡ arrow key decrements the value. When a steady 20 mA reading is obtained on the ammeter press the Enter key to lock in this value and move to the next parameter.

4-20 mA Test (4-20TEST)- The monitor contains a diagnostic routine that allows the simulation of mA values between 4 and 20 to check output tracking. At the **4-20TEST** prompt the arrow keys change the simulated mA output in increments of 1 mA. The ammeter should track the simulated mA output. If a 4-20 mA test is not necessary press MENU once to move to the next parameter.

Password (PASSWORD) - Password protection prevents unauthorized users from changing programming information. Initially the password is set to all zeros. To change the password press **ENTER** once at the password prompt. The first digit of the password value will begin to flash. Using the arrow keys as previously described enter the password value. Pressing **ENTER** will store the password and exit to run mode.

Advanced Setup (ADV STUP) - The advances setup menu allows access to entries for applying scaling factors, enabling or disabling the pulse output, and adding linearization points.
At the **ADV STUP** prompt press ENTER once. The display will now show a steady NO indication. Press the ⬆ arrow key to change to a YES display. Press ENTER once to access the first parameter.

Scale Factor (SCALE F) - At the **SCALE F** prompt press the **ENTER** key once. The current scale factor will begin to flash. If the current selection is correct, press the **ENTER** key to advance to the next parameter.

The scale factor is used to force a global change to all variables. For example, under operating conditions the display is reading a consistent 3% below the expected values at all flow rates. Rather than changing all parameters individually the scale factor can be used to compensate for the 3% offset. The scale factor would be set to 1.03 to correct the readings.

The range of scale factors is from 0.5 to 1.5. The default scale factor is 1.00. A scale factor is used to correct (correlation adjustment) or change the flow value displayed on the LCD.

A correlation adjustment allows the user to “force” the display to read a flow value different from the factory calibrated value. This procedure is only valid for an “offset” difference. In other words the readings must be off by a constant value or percentage for the entire measurement range.

Totalizer Pulse Output (PULS OUT) - The pulse output parameter can be either enabled or disabled. When enabled this output generates a 20 mS duration pulse for every time the least significant digit of the totalizer increments. The amplitude of the pulse is dependent on the voltage level of the supply connected to the pulse output and is limited to a maximum 30 VDC.

Linearization (LINEAR) - Enhanced accuracy can be obtained by linearization of the display. The linearization routine will accept a **maximum of ten** points. Linearization requires additional calibration data from the sensor to be used with the monitor. Typically calibration information is obtained for three, five, or ten points.

Number of Points - At the **LINEAR** prompt press **ENTER** once. The first display number will begin to flash. Again the ⬆ arrow key increments the value and the ➡ arrow moves the cursor between digits. Enter the number of linear points to be used. When the number of points has been input press the **ENTER** key once to move to the first linear segment.

Press the **ENTER** key once and the first linear point's frequency input will begin to flash **FREQ 1**. Enter the frequency for the first linear point using the arrow keys. When the frequency value input is completed, press **ENTER** once again to change to the coefficient value for the first linear point.

At the **COEFF 1** prompt enter the coefficient that corresponds to the frequency value previously entered. Press **ENTER** once to move to the next scaling point.

Continue entering pairs of frequency and coefficient points until all data has been entered.

TOTALIZER FUNCTIONS

Reset Total - To reset the monitor total display, in run mode press **MENU** and **ENTER** simultaneously until **TOTAL RST** starts to flash. The **TOTAL RST** will stop flashing and the display will return to run mode at the conclusion of the reset procedure.

Store Total - The current total can be manually stored in the monitors flash memory. Press and hold the **ENTER** key for 2 seconds. The display will respond with a flashing **TOTALSVD** and then start a display test. At the end of the test the instrument will return to run mode.

Automatic Store Total - The monitor is equipped with a store total feature that works automatically saving the current total to flash memory once every ten minutes.

TROUBLESHOOTING

The RxL series flow meters are designed to ensure long term accuracy and reliability. The material used for construction and self-cleaning strut are specifically designed to withstand the rigors of industrial environments.

As a result, periodic adjustments or re-calibration is not required. The following section is intended as a guide to eliminating common problems found with the installation of the flow meters. Technical assistance is also available directly from Racine Federated, who also provides complete re-calibration and repair service for the RxL series flow meter at nominal cost.

PRELIMINARY CHECKS

The troubleshooting guide of the next section can be used to help locate problems associated with the RxL series flow meter. Before using this guide, the following checks should be made:

1) Is the flow meter cable installed correctly?

2) Is the proper power supplied to the correct terminals?

3) Is the flow meter installed with the flow direction arrow aligned with flow in the pipe?

4) For insertion style flow meters has the sensor head been inserted to the optimum depth?

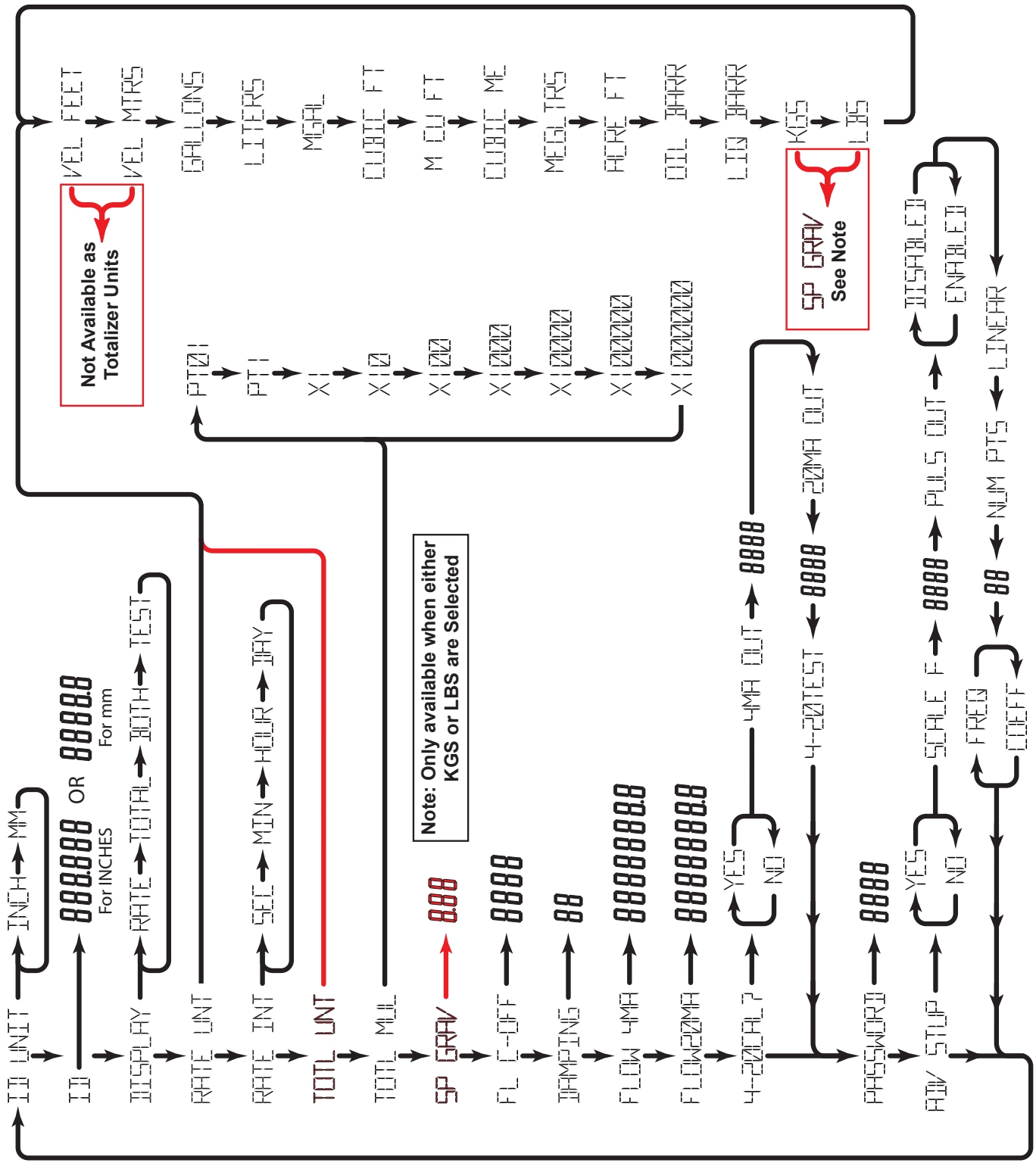


FIGURE 11 - PROGRAMMING FLOW CHART

APPENDIX A - ADDITIONAL INSTALLATION REQUIREMENTS

INTRODUCTION

Installing a flow meter is something which requires careful consideration. It cannot just be placed in a line somewhere and be expected to fulfill its purpose adequately. The geometry and condition of the pipe runs in the area of the installation must be considered to ensure the best and most accurate operation of the flow-meter. This appendix provides suggestions for optimum installations.

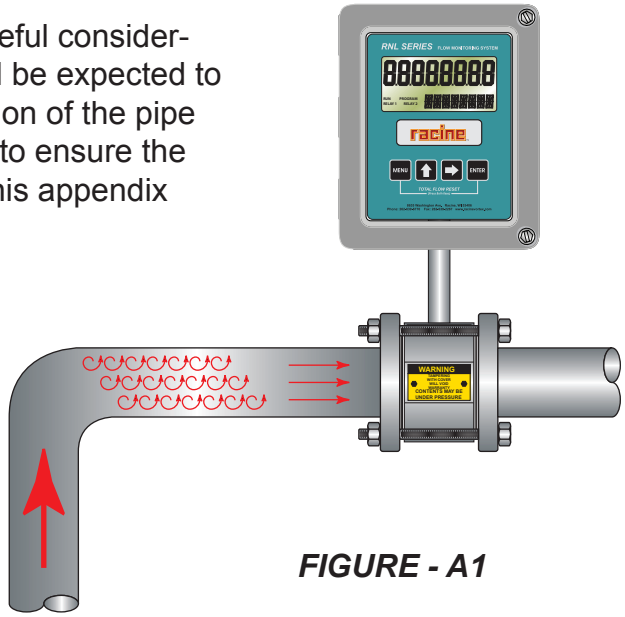


FIGURE - A1

Most flow meter manufacturers define installation conditions in terms of upstream and downstream straight pipe lengths from the point of installation. Unfortunately this is not the only requirement, and one needs to consider other peripheral conditions, such as proximity and style of bends, and other equipment installed in the line. By doing this, problems of turbulence, swirl, and sonic noise may be avoided.

TURBULENCE

Turbulence is a disturbance of the flow caused by bends and obstructions in the flow stream (it is this phenomenon which makes the vortex flow meter work). Fortunately turbulence dies out fairly quickly, so by positioning the flow meter well away from bends and obstructions this potential problem of measuring flow in turbulent conditions is overcome (***See Figure A1***).

SWIRL

Unlike turbulence, swirl will not die away. Once created it will continue until dissipated on the next pipe bend in the system. Swirl occurs after two bends, in close proximity, which are at an angle to each other. When designing an installation, keep the flow meter out of any line which has two adjacent bends upstream. (***See Figure A2***).

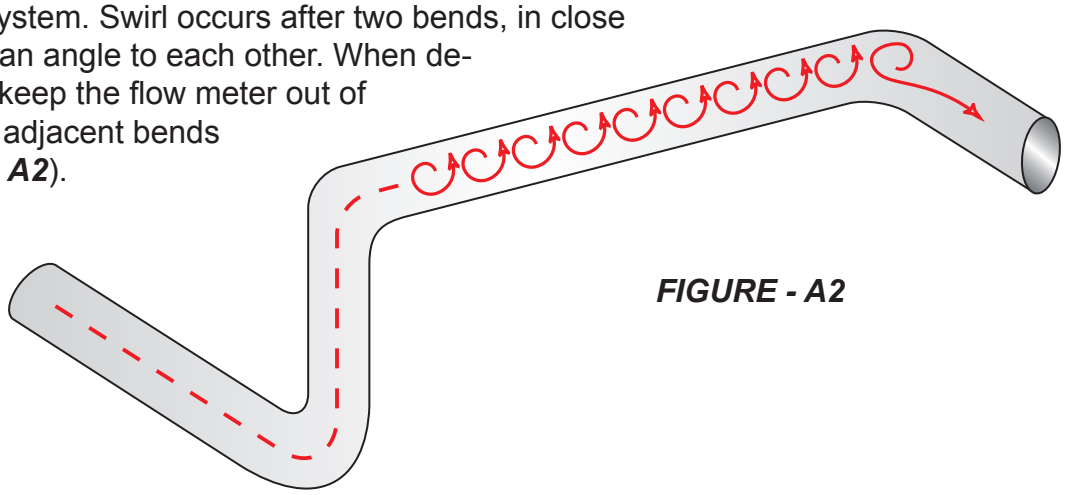


FIGURE - A2

SONIC NOISE

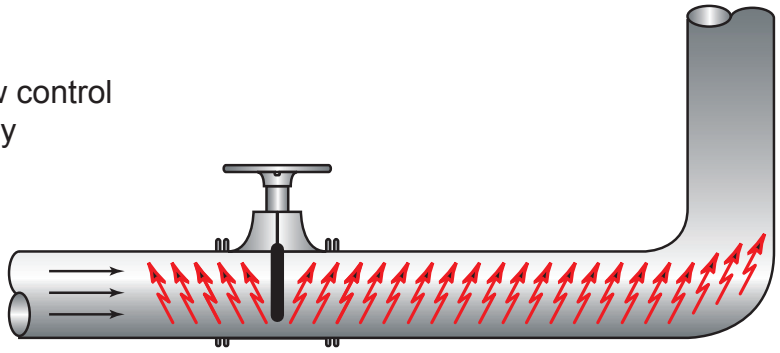


FIGURE A3

Sonic noise is created by valves (either flow control or pressure control valves) which are slightly open. Like swirl, sonic noise will only dissipate on a bend so it is important to install flow meters out of line of sight of valves. Sonic noise is caused by liquid obtaining sonic velocities through a slightly open valve which has a pressure difference across it. This noise travels both up and down stream from the valve therefore the flow meter must be installed well away from the valve, preferably around a bend (***See Figure - A3***).

VELOCITY PROFILE FOR RNL INSERTION METERS

When using an RNL series insertion flow meter, it is necessary to consider the effects of the velocity profile across the pipe or duct to optimize accuracy.

In large pipes, the flow moves slowly at the pipe walls but is at maximum velocity in the center of the pipe creating a continuously variable velocity across the pipe. This velocity variation is called the velocity profile of the pipe, and can be measured and plotted by using the insertion flow meter to measure velocities at various noted positions across the pipe. As the maximum velocity is in the center of the pipe, it follows that if the flow meter is positioned in the center, it will not measure average flow. The “rule of thumb” position is 25% of the pipe ID into the pipe, but the optimum position can only be obtained by measuring the profile and working out the correct position from that.

STRAIGHT-RUN PIPING CONSIDERATIONS

The sensor should be installed with 20 diameters, or more, of straight, unobstructed, full area pipe upstream of the flow meter installation and 10 diameters, or more, downstream. This condition provides a fully developed, symmetrical flow profile that is necessary to obtain accurate and repeatable results. The first obstruction up and downstream should be a full area elbow. If the minimum straight run is not possible, the general rule is to have 80% of the straight run upstream and 20% downstream from the flow meter installation.

High intensity ultrasonic noises should not be located upstream or downstream from the sensor. Common ultrasonic noise sources include the following:

- Slightly cracked valves operating with large pressure drops.
- Small pipe leaks in high pressure systems.
- Venturies operating at near-sonic flow rates.
- Sonic nozzles.

If these ultrasonic noise sources cannot be eliminated, the meter should be mounted with at least one elbow between the flow meter and the noise source.

Temperature and Pressure Tap Locations

User supplied pressure and temperature sensors should be mounted downstream from the flow meter. The pressure sensor should be approximately 3-5 pipe diameters and the temperature sensor approximately 4-8 pipe diameters downstream.

Sensor Installation

The flow meter is shipped completely assembled, tested and ready to install and operate in its permanent location. The RWL wafer style flow meters are designed to mount between two ANSI flanges. The flow meter should be mounted so its inside diameter is centered inside the pipe. The labeling of the flow direction of the flow meter should be aligned with the flow in the pipe. Gaskets (not provided) are necessary between the sensor and the ANSI flanges. Insure that these gaskets are properly installed and do not protrude into the flow stream.

RNL Insertion Style Meter Installation

The RNL series flow meter is shipped completely assembled, tested and ready to install and operate in its permanent location.

If the main line can be depressurized easily without undue user inconvenience, then a simple installation, consisting of a 2” (51 mm) nozzle and a standard ANSI 150 lb, 2” pipe flange may be used. This permits the shortest shaft length to be used, which keeps clearance space requirements for insertion and removal to a minimum. Gaskets (not provided) are necessary between the sensor and ANSI flange. It is recommended that the customer conduct a flow profile survey prior to installing flow meter.

DANGER - Caution should be used when inserting or retracting at pressures exceeding 60 PSIG (4.14 BARg).

Hot Tap Insertion Flow Meter Installation

Where de-pressurizing the line for flow meter maintenance is impossible or undesirable, the “hot tap” method of installation is used. This method involves inserting the flow meter through a 2” (50.76 mm) spool piece and a 2” (50.76 mm) full port valve and will require a longer shaft length as well as greater clearance space for removal and installation.

DANGER - Caution should be used when inserting or retracting at pressures exceeding 60 PSIG (4.14 BARg).

Figure A4 shows a sample hot tap installation. With the exception of the spool piece, which must be a minimum of 6 inches (152 mm) in length, all of the dimensions are suggestions only. Actual dimensions may vary depending on customer’s own hot tap configuration.

To calculate the insertion flow meter stem length for the installation, it will require:

For pipe diameters less than 24” (609 mm): Calculate the distance from the center line of the pipe to the top of the flow meter mounting flange.

For pipe diameters greater than 24” (609 mm): Calculate the distance from the top of the flow meter flange to a point ¼ of the pipe diameter.

Where a flow profile is desirable, calculate the distance from the bottom of the pipe to the top of the flow meter mounting flange and subtract 2” (50.76 mm). Round this distance up to the next largest 12” (305 mm) increment. This is the stem length that should be ordered.

DANGER - Caution should be used when inserting or retracting at pressures exceeding 60 PSIG (4.14 BARg).

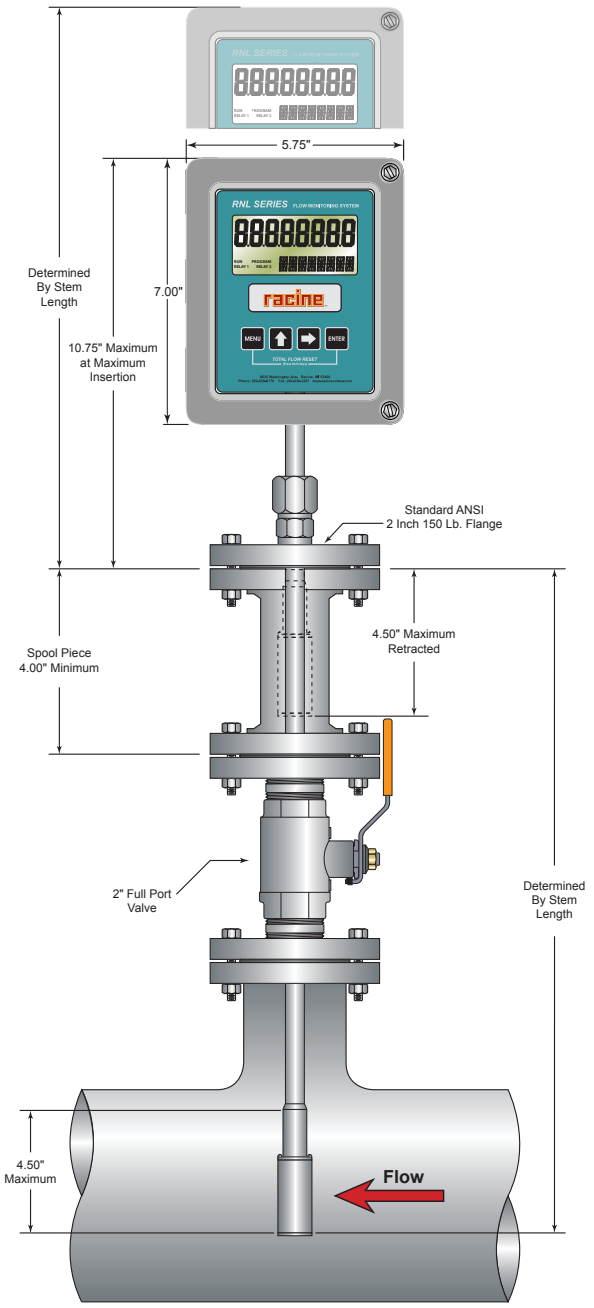


FIGURE A4

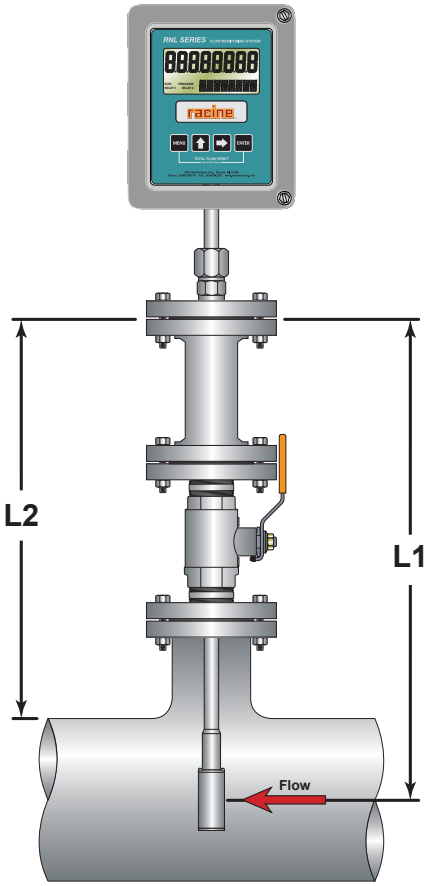


FIGURE A5

L1 = Distance from bottom of flow meter flange to center of vortex strut.

L2 = Distance from bottom of flow meter flange to top inside wall of pipe

1) Find the appropriate L1 distance for your application in the first column.

2) Once the L1 distance is identified, move across the row until the appropriate L2 distance is located for the application. The resulting number is the maximum fluid velocity.

EXAMPLE: L1 length = 24, and L2 length = 12. The resulting maximum fluid velocity is 13 ft/sec.

Table A1 - INSERTION DEPTH
Maximum Fluid Velocity (ft/sec)

L1 Inches	L2 (INCHES)												
	6	8	10	12	14	16	18	20	22	24	26	28	30
10	26	28											
12	22	24	25										
14	20	21	22	24									
16	18	18	19	20	22								
18	16	16	17	18	19	21							
20	15	15	15	16	17	18	20						
22	13	14	14	15	15	16	17	19					
24	13	13	13	13	14	15	15	16	18				
26	12	12	12	12	13	13	14	15	16	17			
28	11	11	11	12	12	12	13	13	14	15	17		
30	10	10	11	11	11	11	12	12	13	14	15	16	
32	10	10	10	10	10	11	11	11	12	12	13	14	15
34	9	9	10	10	10	10	10	11	11	11	12	13	14
36	9	9	9	9	9	9	10	10	10	11	11	12	12

Operating at velocities higher than the values listed in the table may result in bending the stem of the insertion meter.

Flow Profiling

If the purchased flow meter is long enough to be inserted to the far side of the pipe, the flow through the pipe may be profiled at various flow rates. The goal is to find a point in the pipe that remains a consistent percentage of the average flow rate over a wide range of flow. A sample flow profile is shown in Table 7. In this example, the flow rate of a 48 inch pipe is measured every six inches across the diameter of the pipe beginning and ending 3 inches from the near and far sides of the pipe. The distance in inches from the nearside of the pipe is shown. Measurements are taken at a low, medium and high average flow. In Table 8 the flow rate at each measurement point has been converted to a percentage of the average flow. It can be seen that point number three (15 inches from the near side of the pipe) reads a consistent 102 percent of the average flow. The meter should be placed in this position and the output should be divided by 1.02 to obtain the correct reading. Flow profiling should be done for all insertion meter installations.

Reducing the Pipe Diameter

To decrease the variation of flow profile, the piping can be narrowed at the flow meter as shown in ***Figure A6***. This will smooth the flow and increase the effectiveness of flow profiling. Nearly any angle can be used on the down-stream side of the meter to restore the original pipe diameter. However, if the angle of piping is seven degrees or less, nearly all the pressure drop caused by the narrow pipe section will be recovered.

TABLE 7 - FLOW PROFILE (RAW DATA)

FLOW	FLOW RATE AT MEASUREMENT POINT (F/S)								
	1	2	3	4	5	6	7	8	AVERAGE (ft/s)
LOW FLOW	1.90	2.00	2.04	2.06	2.06	2.04	2.00	1.90	2.0
MEDIUM FLOW	5.58	5.91	6.12	6.21	6.24	6.18	6.06	5.70	6.0
HIGH FLOW	10.92	11.70	12.24	12.48	12.60	12.48	12.18	11.40	12.0
DISTANCE	**3**	**9**	**15**	**21**	**27**	**33**	**39**	**45**	**INCHES**

TABLE 8 - FLOW PROFILE (NORMALIZED DATA)

FLOW	FLOW RATE AT MEASUREMENT POINT (%)							
	1	2	3	4	5	6	7	8
LOW FLOW	95.0	100.0	102.0	103.0	103.0	102.0	100.0	95.0
MEDIUM FLOW	93.0	98.5	102.0	103.5	104.0	103.0	101.0	95.0
HIGH FLOW	91.0	97.5	102.0	104.0	105.0	104.0	101.5	95.0

"STEEL, STAINLESS STEEL, P.V.C. PIPE"
STANDARD CLASSES

Nominal Pipe Size Inches	Outside Diameter	SCH 5		SCH 10 (Lt Wall)		SCH 20		SCH 30		STD		SCH 40	
		ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall
1	1.315	1.185	0.065	1.097	0.109					1.049		1.049	0.133
1.25	1.660	1.53	0.065	1.442	0.109					1.380		1.380	0.140
1.5	1.900	1.77	0.065	1.682	0.109					1.610		1.610	0.145
2	2.375	2.245	0.065	2.157	0.109					2.067		2.067	0.154
2.5	2.875	2.709	0.083	2.635	0.120					2.469		2.469	0.203
3	3.500	3.334	0.083	3.260	0.120					3.068		3.068	0.216
3.5	4.000	3.834	0.083	3.760	0.120					3.548		3.548	0.226
4	4.500	4.334	0.083	4.260	0.120					4.026	0.237	4.026	0.237
5	5.563	5.345	0.109	5.295	0.134					5.047	0.258	5.047	0.258
6	6.625	6.407	0.109	6.357	0.134					6.065	0.280	6.065	0.280
8	8.625	8.407	0.109	8.329	0.148	8.125	0.250	8.071	0.277	7.981	0.322	7.981	0.322
10	10.75	10.482	0.134	10.42	0.165	10.25	0.250	10.13	0.310	10.02	0.365	10.02	0.365
12	12.75	12.42	0.165	12.39	0.180	12.25	0.250	12.09	0.330	12.00	0.375	11.938	0.406
14	14.00			13.50	0.250	13.37	0.315	13.25	0.375	13.25	0.375	13.124	0.438
16	16.00			15.50	0.250	15.37	0.315	15.25	0.375	15.25	0.375	15.000	0.500
18	18.00			17.50	0.250	17.37	0.315	17.12	0.440	17.25	0.375	16.876	0.562
20	20.00			19.50	0.250	19.25	0.375	19.25	0.375	19.25	0.375	18.814	0.593
24	24.00			23.50	0.250	23.25	0.375	23.25	0.375	23.25	0.375	22.626	0.687
30	30.00			29.37	0.315	29.00	0.500	29.00	0.500	29.25	0.375	29.25	0.375
36	36.00			35.37	0.315	35.00	0.500	35.00	0.500	35.25	0.375	35.25	0.375
42	42.00									41.25	0.375	41.25	0.375
48	48.00									47.25	0.375	47.25	0.375

"STEEL, STAINLESS STEEL, P.V.C. PIPE"
STANDARD CLASSES

Nominal Pipe Size Inches	Outside Diameter	SCH 60		X STG.		SCH 80		SCH 100		SCH 120/140		SCH 180	
		ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall	ID	Wall
1	1.315			0.957	0.179	0.957	0.179					0.815	0.250
1.25	1.660			1.278	0.191	1.278	0.191					1.160	0.250
1.5	1.900			1.500	0.200	1.500	0.200					1.338	0.281
2	2.375			1.939	0.218	1.939	0.218					1.687	0.344
2.5	2.875			2.323	0.276	2.323	0.276					2.125	0.375
3	3.500			2.900	0.300	2.900	0.300					2.624	0.438
3.5	4.000			3.364	0.318	3.364	0.318						
4	4.500			3.826	0.337	3.826	0.337			3.624	0.438	3.438	0.531
5	5.563			4.813	0.375	4.813	0.375			4.563	0.500	4.313	0.625
6	6.625			5.761	0.432	5.761	0.432			5.501	0.562	5.187	0.719
8	8.625	7.813	0.406	7.625	0.500	7.625	0.500	7.437	0.594	7.178	0.719	6.183	1.221
10	10.75	9.750	0.500	9.75	0.500	9.562	0.594	9.312	0.719	9.062	0.844	8.500	1.125
12	12.75	11.626	0.562	11.75	0.500	11.37	0.690	11.06	0.845	10.75	1.000	10.12	1.315
14	14.00	12.814	0.593	13.00	0.500	12.50	0.750	12.31	0.845	11.81	1.095	11.18	1.410
16	16.00	14.688	0.656	15.00	0.500	14.31	0.845	13.93	1.035	13.56	1.220	12.81	1.595
18	18.00	16.564	0.718	17.00	0.500	16.12	0.940	15.68	1.160	15.25	1.375	14.43	1.785
20	20.00	18.376	0.812	19.00	0.500	17.93	1.035	17.43	1.285	17.00	1.500	16.06	1.970
24	24.00	22.126	0.937	23.00	0.500	21.56	1.220	20.93	1.535	20.93	1.535	19.31	2.345
30	30.00			29.00	0.500								
36	36.00			35.00	0.500								
42	42.00			41.00	0.500								
48	48.00			47.00	0.500								

Cast Iron Pipe (Standard Classes)

Size (Inches)		Class							
		A	B	C	D	E	F	G	H
3”	O.D.	3.80	3.96	3.96	3.96				
	Wall	0.39	0.42	0.45	0.48				
	I.D.	3.02	3.12	3.06	3.00				
4”	O.D.	4.80	5.00	5.00	5.00				
	Wall	0.42	0.45	0.48	0.52				
	I.D.	3.96	4.10	4.04	3.96				
6”	O.D.	6.90	7.10	7.10	7.10	7.22	7.22	7.38	7.38
	Wall	0.44	0.48	0.51	0.55	0.58	0.61	0.65	0.69
	I.D.	6.02	6.14	6.08	6.00	6.06	6.00	6.08	6.00
8”	O.D.	9.05	9.05	9.30	9.30	9.42	9.42	9.60	9.60
	Wall	0.46	0.51	0.56	0.60	0.66	0.66	0.75	0.80
	I.D.	8.13	8.03	8.18	8.10	8.10	8.10	8.10	8.00
10”	O.D.	11.10	11.10	11.40	11.40	11.60	11.60	11.84	11.84
	Wail	0.50	0.57	0.62	0.68	0.74	0.80	0.86	0.92
	I.D.	10.10	9.96	10.16	10.04	10.12	10.00	10.12	10.00
12”	O.D.	13.20	13.20	13.50	13.50	13.78	13.78	14.08	14.08
	Wall	0.54	0.62	0.68	0.75	0.82	0.89	0.97	1.04
	I.D.	12.12	11.96	12.14	12.00	12.14	12.00	12.14	12.00
14”	O.D.	15.30	15.30	15.65	15.65	15.98	15.98	16.32	16.32
	Wall	0.57	0.66	0.74	0.82	0.90	0.99	1.07	1.16
	I.D.	14.16	13.98	14.17	14.01	14.18	14.00	14.18	14.00
16”	O.D.	17.40	17.40	17.80	17.80	18.16	18.16	18.54	18.54
	Wall	0.60	0.70	0.80	0.89	0.98	1.08	1.18	1.27
	I.D.	16.20	16.00	16.20	16.02	16.20	16.00	16.18	16.00
18”	O.D.	19.50	19.50	19.92	19.92	20.34	20.34	20.78	20.78
	Wall	0.64	0.75	0.87	0.96	1.07	1.17	1.28	1.39
	I.D.	18.22	18.00	18.18	18.00	18.20	18.00	18.22	18.00
20”	O.D.	21.60	21.60	22.06	22.06	22.54	22.54	23.02	23.02
	Wall	0.67	0.80	0.92	1.03	1.15	1.27	1.39	1.51
	I.D.	20.26	20.00	20.22	20.00	20.24	20.00	20.24	20.00

Size (Inches)		Class							
		A	B	C	D	E	F	G	H
24”	O.D.	25.80	25.80	26.32	26.32	26.90	26.90	27.76	27.76
	Wall	0.76	0.98	1.05	1.16	1.31	1.45	1.75	1.88
	I.D.	24.28	24.02	24.22	24.00	24.28	24.00	24.26	24.00
30”	O. D.	31.74	32.00	32.40	32.74	33.10	33.46		
	Wall	0.88	1.03	1.20	1.37	1.55	1.73		
	I.D.	29.98	29.94	30.00	30.00	30.00	30.00		
36”	O.D.	37.96	38.30	38.70	39.16	39.60	40.04		
	Wall	0.99	1.15	1.36	1.58	1.80	2.02		
	I.D.	35.98	36.00	35.98	36.00	36.00	36.00		
42”	O.D.	44.20	44.50	45.10	45.58				
	Wall	1.10	1.28	1.54	1.78				
	I.D.	42.00	41.94	42.02	42.02				
48”	O.D.	50.55	50.80	51.40	51.98				
	Wall	1.26	1.42	1.71	1.99				
	I.D.	47.98	47.96	47.98	48.00				
54”	O.D.	56.66	57.10	57.80	58.40				
	Wall	1.35	1.55	1.90	2.23				
	I.D.	53.96	54.00	54.00	53.94				
60”	O.D.	62.80	63.40	64.20	64.28				
	Wall	1.39	1.67	2.00	2.38				
	I.D.	60.02	60.06	60.20	60.06				
72”	O.D.	75.34	76.00	76.88					
	Wall	1.62	1.95	2.39					
	I.D.	72.10	72.10	72.10					
84”	O.D.	87.54	88.54						
	Wall	1.72	2.22						
	I.D.	84.10	84.10						

Ductile Iron Pipe (Standard Classes)

Size (Inches)		Class							Mortar Lining
		50	51	52	53	54	55	56	
3”	O.D.		3.96	3.96	3.96	3.96	3.96	3.96	Std. 0.123 Dbl. 0.250
	Wall		0.25	0.28	0.31	0.34	0.37	0.41	
	I.D.		3.46	3.40	3.34	3.28	3.22	3.14	
4”	O.D.		4.80	4.80	4.80	4.80	4.80	4.80	Std. 0.123 Dbl. 0.250
	Wall		0.26	0.29	0.32	0.35	0.38	0.42	
	I.D.		4.28	4.22	4.16	4.10	4.04	3.93	
6”	O.D.	6.90	6.90	6.90	6.90	6.90	6.90	6.90	Std. 0.123 Dbl. 0.250
	Wall	0.25	0.28	0.31	0.34	0.37	0.40	0.43	
	I.D.	6.40	6.34	6.28	6.22	6.16	6.10	6.04	
8”	O.D.	9.05	9.05	9.05	9.05	9.05	9.05	9.05	Std. 0.123 Dbl. 0.250
	Wall	0.27	0.30	0.33	0.36	0.39	0.42	0.45	
	I.D.	8.51	8.45	8.39	8.33	8.27	8.21	8.15	
10”	O.D.	11.10	11.10	11.10	11.10	11.10	11.10	11.10	Std. 0.123 Dbl. 0.250
	Wall	0.39	0.32	0.35	0.38	0.41	0.44	0.47	
	I.D.	10.32	10.46	10.40	10.34	10.28	10.22	10.16	
12”	O.D.	13.20	13.20	13.20	13.20	13.20	13.20	13.20	Std. 0.123 Dbl. 0.250
	Wall	0.31	0.34	0.37	0.40	0.43	0.46	0.49	
	I.D.	12.58	12.52	12.46	12.40	12.34	12.28	12.22	
14”	O.D.	15.30	15.30	15.30	15.30	15.30	15.30	15.30	Std . 0.1875 Dbl. 0.375
	Wall	0.33	0.36	0.39	0.42	0.45	0.48	0.51	
	I.D.	14.64	14.58	14.52	14.46	14.40	14.34	14.28	
16”	O.D.	17.40	17.40	17.40	17.40	17.40	17.40	17.40	Std . 0.1875 Dbl. 0.375
	Wall	0.34	0.37	0.40	0.43	0.46	0.49	0.52	
	I.D.	16.72	16.66	16.60	16.54	16.48	16.42	16.36	

Size (Inches)		Class							Mortar Lining
		50	51	52	53	54	55	56	
18”	O.D.	19.50	19.50	19.50	19.50	19.50	19.50	19.50	Std . 0.1875 Dbl. 0.375
	Wall	0.35	0.38	0.41	0.44	0.47	0.50	0.53	
	I.D.	18.80	18.74	18.68	18.62	18.56	18.50	18.44	
20”	O.D.	21.60	21.60	21.60	21.60	21.60	21.60	21.60	Std . 0.1875 Dbl. 0.375
	Wall	0.36	0.39	0.42	0.45	0.48	0.51	0.54	
	I.D.	20.88	20.82	20.76	20.70	20.64	20.58	20.52	
24”	O.D.	25.80	25.80	25.80	25.80	25.80	25.80	25.80	Std . 0.1875 Dbl. 0.375
	Wall	0.38	0.41	0.44	0.47	0.50	0.53	0.56	
	I.D.	25.04	24.98	24.92	24.86	24.80	24.74	24.68	
30”	O. D.	32.00	32.00	32.00	32.00	32.00	32.00	32.00	Std. 0.250 Dbl. 0.500
	Wall	0.39	0.43	0.47	0.51	0.55	0.59	0.63	
	I.D.	31.22	31.14	31.06	30.98	30.90	30.82	30.74	
36”	O.D.	38.30	38.30	38.30	38.30	38.30	38.30	38.30	Std. 0.250 Dbl. 0.500
	Wall	0.43	0.48	0.62	0.58	0.45	0.68	0.73	
	I.D.	37.44	37.34	37.06	37.14	37.40	36.94	36.48	
42”	O.D.	44.50	44.50	44.50	44.50	44.50	44.50	44.50	Std. 0.250 Dbl. 0.500
	Wall	0.47	0.53	0.59	0.65	0.71	0.77	0.83	
	I.D.	43.56	43.44	43.32	43.20	43.08	42.96	42.84	
48”	O.D.	50.80	50.80	50.80	50.80	50.80	50.80	50.80	Std. 0.250 Dbl. 0.500
	Wall	0.51	0.58	0.65	0.72	0.79	0.86	0.93	
	I.D.	49.78	49.64	49.50	49.36	49.22	49.08	48.94	
54”	O.D.	57.10	57.10	57.10	57.10	57.10	57.10	57.10	Std. 0.250 Dbl. 0.500
	Wall	0.57	0.65	0.73	0.81	0.89	0.97	1.05	
	I.D.	55.96	55.80	55.64	55.48	55.32	55.16	55.00	

Nominal Diameter		COPPER TUBING Type K	COPPER TUBING Type L	COPPER TUBING Type M	Copper & Brass Pipe	ALUMINUM
1/2"	O. D.	0.625	0.625	0.625	0.840	
	Wall	0.049	0.040	0.028	0.108	
	I.D.	0.527	0.545	0.569	0.625	
5/8"	O. D.	0.750	0.750	0.750		
	Wall	0.049	0.042	0.030		
	I.D.	0.652	0.666	0.690		
3/4"	O. D.	0.875	0.875	0.875	1.050	
	Wall	0.065	0.045	0.032	0.114	
	I.D.	0.745	0.785	0.811	0.822	
1"	O. D.	1.125	1.125	1.125	1.315	
	Wall	0.065	0.050	0.035	0.127	
	I.D.	0.995	1.025	1.055	1.062	
1-¼"	O. D.	1.375	1.375	1.375	1.660	
	Wail	0.065	0.055	0.042	0.146	
	I.D.	1.245	1.265	1.291	1.368	
1-½"	O. D.	1.625	1.625	1.625	1.900	
	Wall	0.072	0.060	0.027	0.150	
	I.D.	1.481	1.505	1.571	1.600	
2"	O. D.	2.125	2.125	2.125	2.375	
	Wall	0.083	0.070	0.058	0.157	
	I.D.	1.959	1.985	2.009	2.062	
2 ½"	O. D.	2.625	2.625	2.625	2.875	2.500
	Wall	0.095	0.080	0.065	0.188	0.050
	I.D.	2.435	2.465	2.495	2.500	2.400
3"	O. D.	3.125	3.125	3.125	3.500	3.000
	Wall	0.109	0.090	0.072	0.219	0.050
	I.D.	2.907	2.945	2.981	3.062	2.900

Nominal Diameter		COPPER TUBING Type K	COPPER TUBING Type L	COPPER TUBING Type M	Copper & Brass Pipe	ALUMINUM
3½"	O. D.	3.625	3.625	3.625	4.000	
	Wall	0.120	0.100	0.083	0.250	
	I.D.	3.385	3.425	3.459	3.500	
4"	O. D.	4.125	4.125	4.125	4.500	4.000
	Wall	0.063	0.134	0.110	0.095	0.250
	I. D.	3 874	3.857	3.905	3.935	4.000
4-½"	O D.					5.000
	Wall					0.250
	I. D.					4.500
5"	0. D.	5.125	5.125	5.125	5.563	5.000
	Wall	0.160	0.125	0.109	0.250	0.063
	I. D.	4.805	4.875	4.907	5.063	4.874
6"	0. D.	6.125	6.125	6.125	6.625	6.000
	Wall	0.192	0.140	0.122	0.250	0.063
	ID.	5.741	5.845	5.881	6.125	5.874
7"	O. D				7.625	7.000
	Wall				0.282	0.078
	I. D.				7.062	6.844
8"	O D	8.125	8.125	8.125	8.625	8 000
	Wall	0,271	0.200	0.170	0.313	0.094
	I. D.	7.583	7.725	7.785	8.000	7.812
10"	0. D.				10 000	
	Wall				0.094	
	I. D.				9.812	

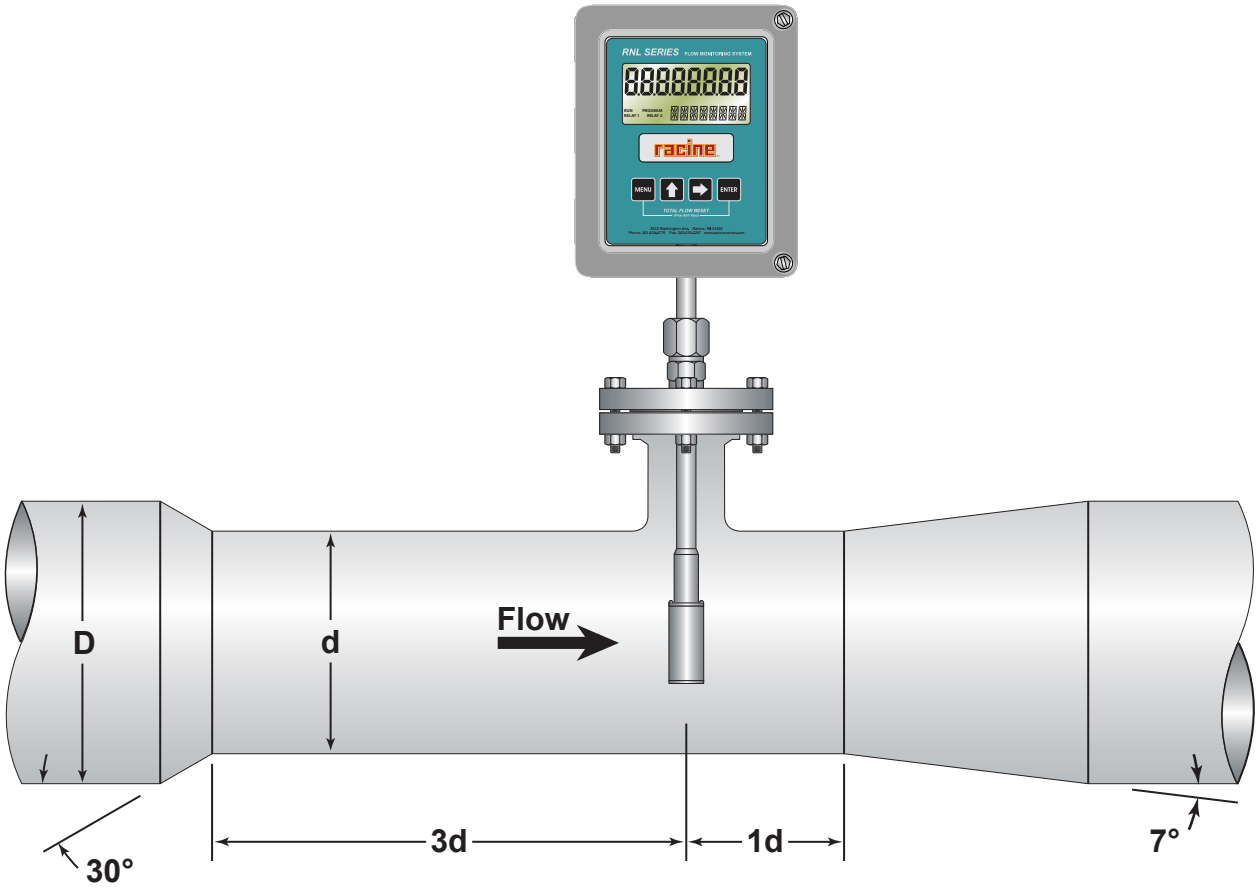


FIGURE A6 - INSERTION FLOW METER INSTALLED IN A REDUCED PIPE

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